Final Report - Contract Nonr-1163(00)

Fabrication of Four Test Discs

May 19, 1954

LABORATORY REPORT

KENNAMETAL Inc.

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Latrobe, Pa.

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Fabrication of Four Test Discs

PURPOSE:

The purpose of the work successfully completed under this contract was the fabrication of four spin test discs of titanium carbide compositions for test at the Boeing Airplane Company. Kennametal was required to give the benefit of its experience with design, fabrication and operation of small integral impellers to assist in the design of suitable test specimens. It was also necessary, based on the physical properties of various titanium carbide compositions and test experience with them, to recommend proper materials from which to fabricate the specimens to withstand the conditions contemplated by Boeing in their test program. Finally, the four specimens had to be fabricated through all steps from the raw materials by powder metallurgy processes and finish ground to accurate dimensions.

WORK PERFORMED:

One of Kennametal's engineers visited the Boeing Airplane Company at the beginning of the contract and discussed with them our experience in the design and test operation of fastenings for attachment of titanium carbide composition integral discs to the shaft in such a way as to minimise stress concentrations. This involves the avoidance of holes and threaded connections by provision of a hub on the face of the disc which hub is gripped preferably externally to put the carbide insofar as possible in compression. A centering boss is required to keep the disc concentric with the shaft. Based on these principles, the general outline of the attachment and assembly was agreed upon during the conference. Boeing subsequently completed the details of the designs which are shown in drawing No. JM-539.

The choice of material had next to be made to meet the test conditions prescribed by Boeing. Two conditions are eventually to be met.

1. Hot spin at 36,000 rpm for 100 hours at 1350°F blade tip temperature.

2. Hot spin at 36,000 rpm for 100 hours at 1650°F blade tip temperature.

The compositions recommended for consideration together with their properties are listed in Table I. These are all nickel bonded compositions. In addition to the properties listed, the experience of turbine testing was taken into account. It was concluded that the minimum binder content of 40 percent would be required to insure sufficient toughness in the center portion of the disc and would at the same time retain sufficient high temperature strength for the rim and blades.

Since Kennametal had available a process for welding together two different titanium carbide compositions, it was also proposed that composite specimens be made having the 30 percent binder material in the blades and rim section to provide even better resistance to stress at high temperatures and higher binder, tougher material in the center. Two composite specimens were proposed as shown in drawing JM-501. Both of these specified K152B in the blades and rim. Item 2 has K153B in the center section and Item 3 has K154B.

The compositions and designs recommended were approved and fabrication undertaken. This was by Kennametal's standard procedure for titanium carbide compositions. The ball milled powders were packed in rubber envelopes shaped approximately to the overall shape of the finished specimens and hydrostatically pressed using the large "explosive" pressing chamber. Pressure was approximately 35,000 psi in all cases. The pressed "slugs" were then trued up by grinding and machining and were then presintered. Thereafter, the machining of most of the final detail was carried out allowing, of course, for shrinkage during final sintering and stock for final grinding. In the case of the composite specimens, the hub and rim sections were each made separately. Sintering of all parts was carried out in vacuum with the parts supported on suitably shaped graphite supports.

After sintering, the mating surfaces of the parts of the composite specimens had to be accurately ground to match by cylindrical grinding. The parts were then assembled with a .002 thick nickel shim inserted completely around between them. They were then reheated in the vacuum furnace. Excellent joints were obtained as evidenced by visual and penetrant inspection. Previous work had shown that these joints are strong and can barely be detected metallographically since the nickel diffuses into the adjoining areas.

The final work consisted in grinding the specimens all over (except on the blade faces and fillets) to final dimensions. Since we had not previously made discs of this size and configuration, minor difficulties with shrinkage allowance were encountered which necessitated small deviations from a few drawing dimensions. These were acceptable to Boeing for their test work. Based on the present experience, no difficulty should be experienced in the future.

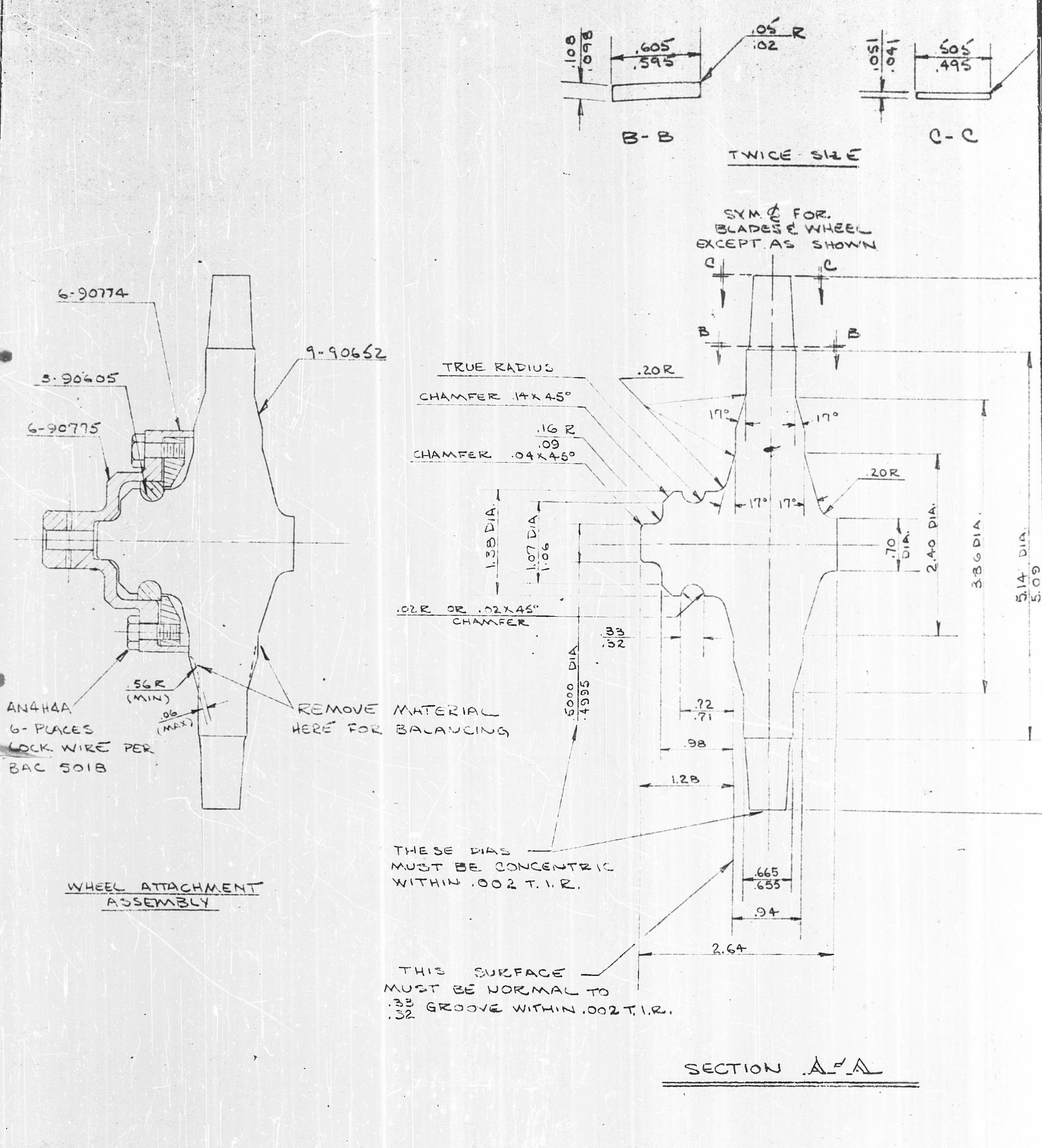
Aside from the above problem, no difficulties were experienced in the fabrication of these specimens. No pieces were lost and none had to be rejected. The last two specimens were shipped to Boeing Airplane Company on February 19, 1954. Two views of the first rotor shipped are shown in photographs 2147A and 2147B.

May 19, 1954

TABLE I

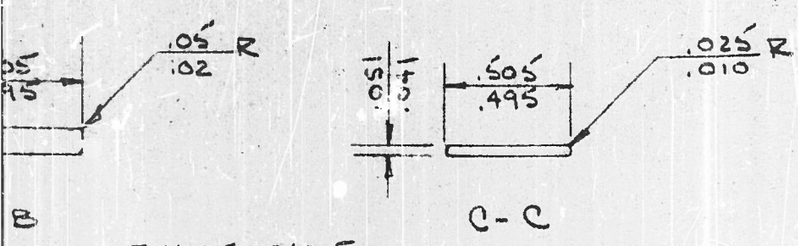
PHYSICAL PROPERTY DATA OF K150 SERIES KENTANIUM COMPOSITIONS

Grade	Binder Content %	Density g/cc	Hardness RA	Modulus of Rupture psi	Modulus of Elasticity psi	Coefficient of Expansion in./in./°F x 10-6	Thermal Conductivity cal./°C/cm/sec.	Tensile Strength psi	100 Hour Life Rupture Strength 1600°F psi	100 Hour Life Rupture Strength 1800°F psi
K152B	30	6.0	85.0	210,000	47,000,000	5.3	.0766	130,000	19,500	6,500
K153B	40	6.3	82.8	185,000	41,000,000	5.6	—	111,000	16,000	5,500
K154B	50	6.44	80.9	235,000	41,000,000	6.2	—	115,000	—	—

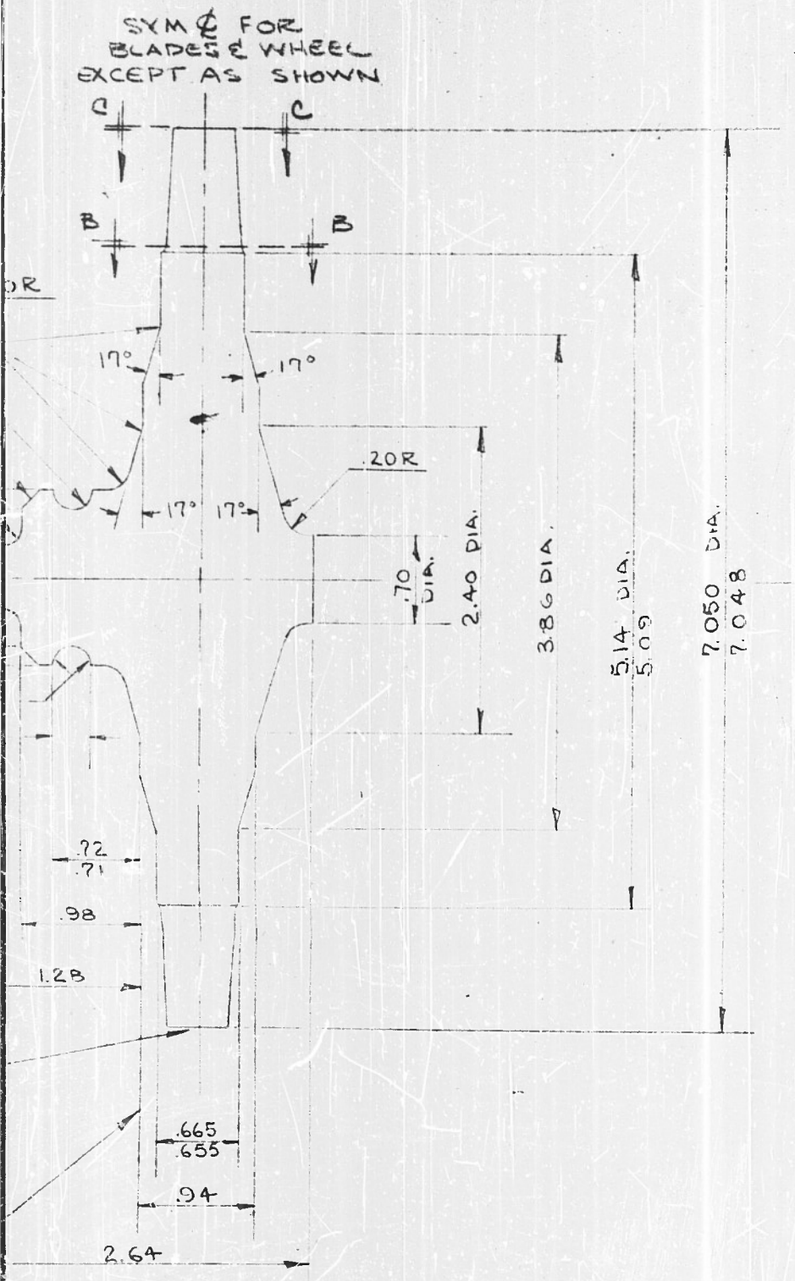


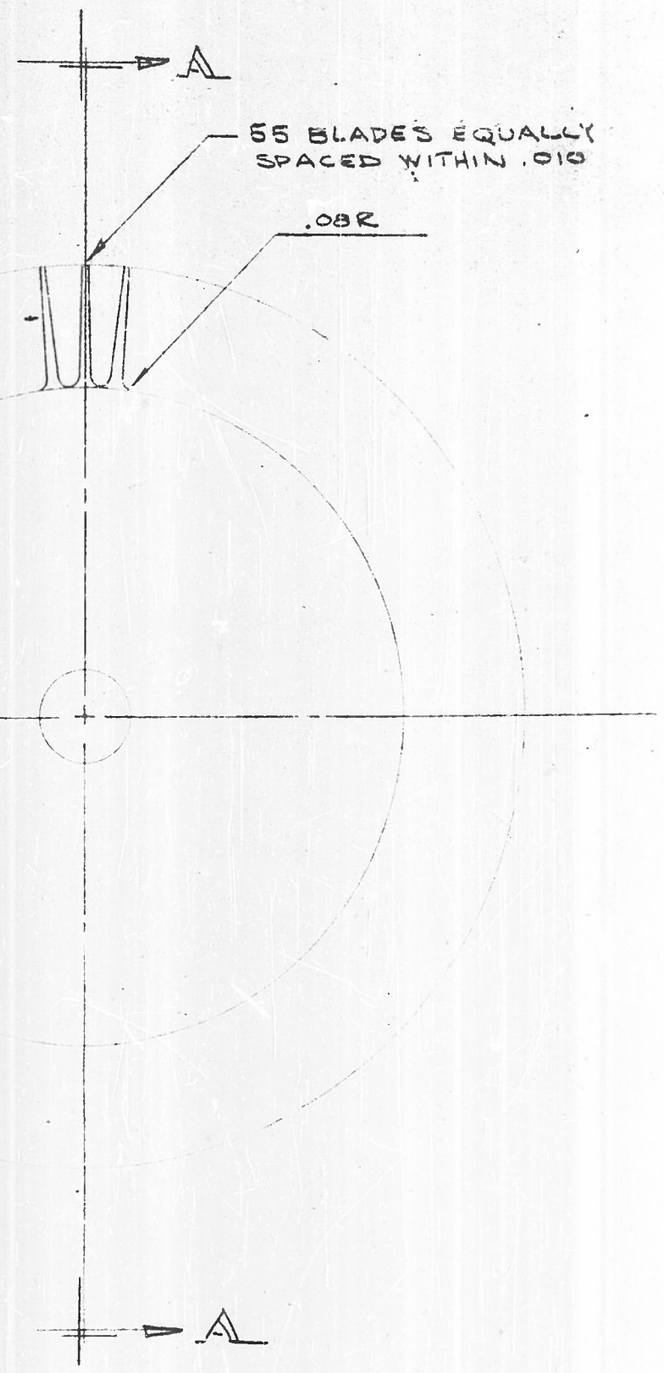
1

SCALE FULL SIZE



TWICE SIZE





REF. DWG. BOEING AIRPLANE CO.
9-90652 & 9-90653

SECTION A-A

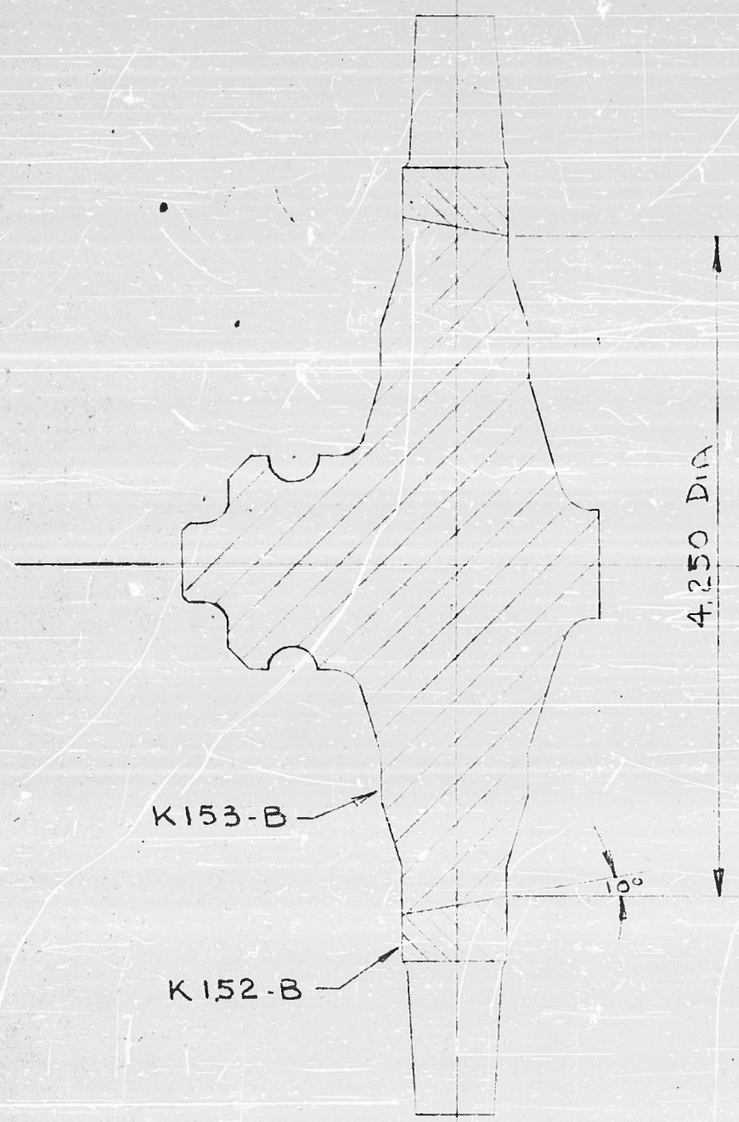
TOLERANCES	
ANGLES ± 1°	UNLESS SPECIFIED OTHERWISE
FRACTIONS ± .010"	
3 PLACE DECIMALS ± .005"	

KENNAMETAL INC.
LATROBE, PA.

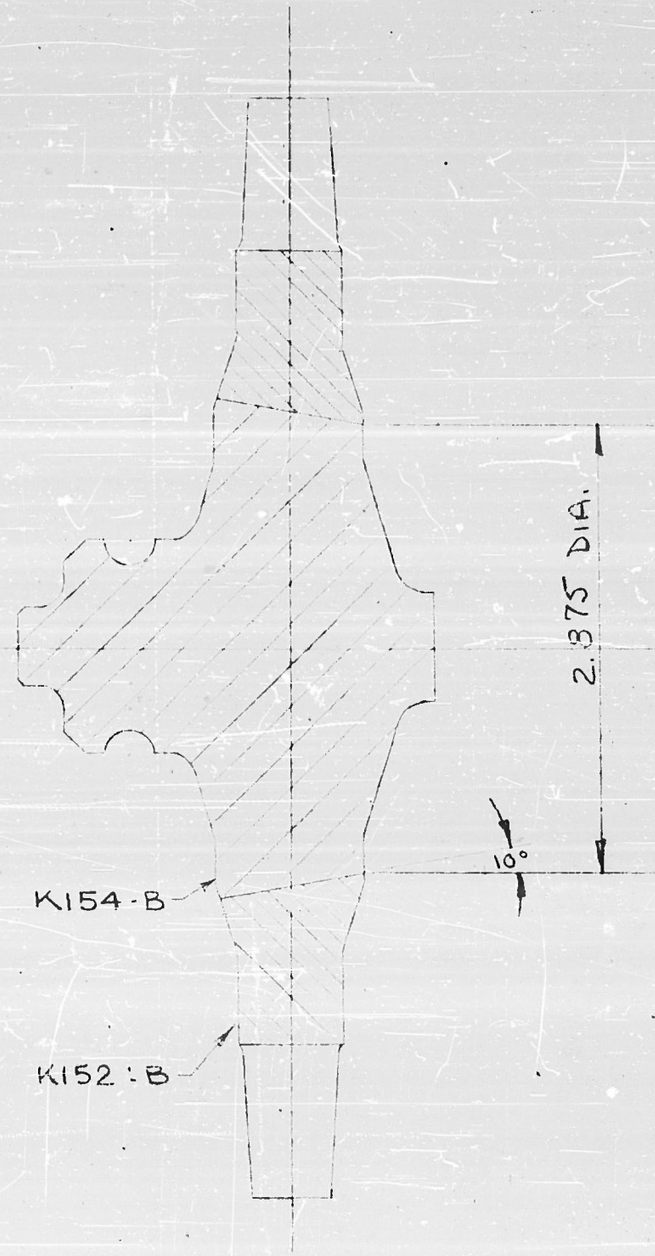
Customer's Name: TURBINE WHEEL SPIN TEST SPECIMEN (TEST ONLY)

Cust. Dwg. No.	Cust. Part No.
Date 5-19-54	DWG. No. JM-539
Dwn. by RJR	
Ch'd by	

PR 1337-852



ITEM 2



ITEM 3

SCALE - FULL SIZE

ISSUED
JUL 22 1954
KENNAMETAL INC.

REF. DWG. (BOEING 9-90652)

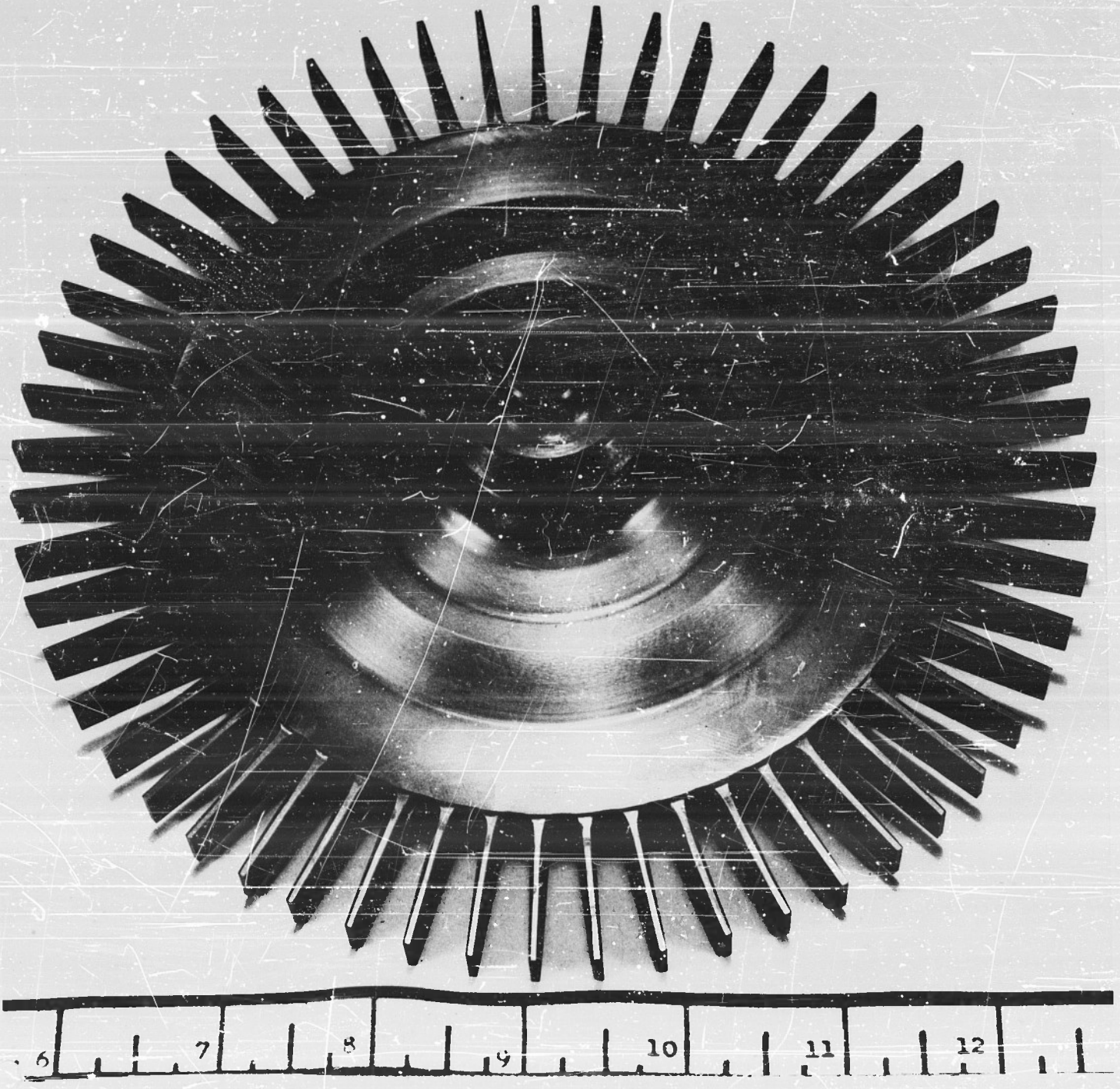
TOLERANCES	
ANGLES ± 1° FRACTIONS ± .010" 3 PLACE DECIMALS ± .005"	UNLESS SPECIFIED OTHERWISE

KENNAMETAL INC.
LATROBE, PA.

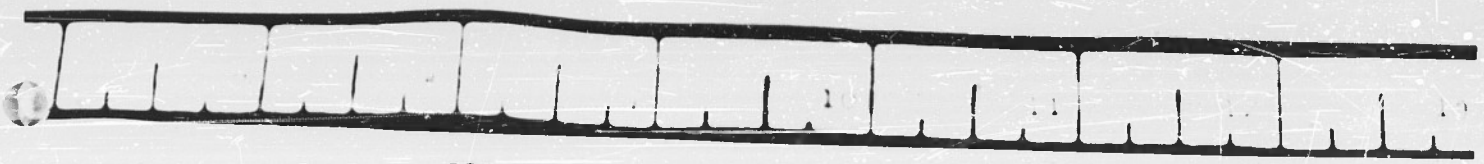
Customer's Name
COMPOSITE TURBINE WHEEL

Cust. Dwg. No.	*Cust. Part No.*

Date 6/24/53	DWG. No.
Dwn. by R.J.P.	JM-501
Ch'd by	



K153B Spin Test Specimen
Contract NOnr-1163(oo) 2147-A



K153B Spin Test Specimen
Contract NOnr-1163(oo) 2147-B